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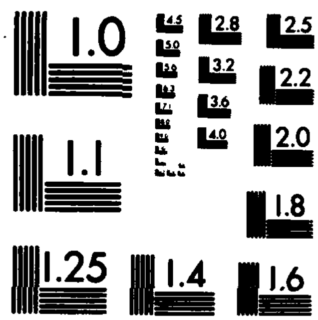

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USAAVRADCOM
TECHNICAL REPORT TR 83-F-4

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REVIEW OF HISTORICAL INFLATION INDICES APPLICABLE TO ARMY AVIATION

MARK W. GLENN, OPERATIONS RESEARCH ANALYST
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MARCH 1983

FINAL REPORT

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US ARMY AVIATION RESEARCH AND DEVELOPMENT COMMAND
DIRECTORATE FOR PLANS AND ANALYSIS
DATA ANALYSIS AND CONTROL DIVISION
4300 GOODFELLOW BOULEVARD
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This report discusses inflation indices, their derivation, interpretation and their importance in program evaluation and management. The characteristics of different types of inflation indices are presented. Various indices developed by this office are reviewed along with indices provided by the US Army Materiel Development and Readiness Command (DARCOM), Office of the Secretary of Defense (OSD) and by certain nondefense agencies. The indices are compared and then conclusions derived which assess their relative effectiveness in reflecting actual price movements in Army Aviation Research and Development.

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After theoretical discussion, a new index is proposed that incorporates input-output analysis. Suggestions for further research are presented.

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I. BACKGROUND.

A. The Directorate for Plans and Analysis, US Army Aviation Research and Development Command (USAAVRADCOM), has within the scope of its mission the responsibility to serve as the Command focal point for inflation guidance (DARCOM Regulation 37-4). Some of this responsibility is satisfied by disseminating Office of the Secretary of Defense (OSD) Inflation Indices to the various command elements. This, in itself, is a relatively simple task and is routinely carried out. Certain programs, nonetheless, require inflation guidance peculiar to their own program. The Remotely Piloted Vehicle (RPV), for instance, is unique in certain respects because it is neither a rotary winged aircraft nor a piloted fixed winged system. Consequently, inflation indices made from either rotary or fixed winged systems are not appropriate for the RPV except for purposes of approximation. Since a more realistic index was desired for the RPV program, the Directorate assumed its mission responsibility by providing the RPV Program Manager (PM) with a set of indices derived from research conducted within the Directorate, itself.

B. The purpose of this report is to extend that portion of the Directorate's overall research effort which is aimed at providing the Command with accurate and timely inflation indices. Various indices developed by this office are reviewed along with historical indices provided by the US Army Development and Material Readiness Command (DARCOM), the Office of the Secretary of Defense (OSD) and by certain nondefense agencies. The source of reference for the indices developed outside the Directorate for Plans and Analysis is a letter from HQ DARCOM, DRCCP-ER, 14 August 1981, subject: DARCOM Historical Inflation Review (Reference 1).

C. This report should be of interest not only to cost analysts interested in aviation research and development, but also to cost analysts in other fields as well. The theoretical discussion centers on the Laspeyres index and the Paasche index, although other price indices such as the "Ideal" index and the weighted average of relatives index are briefly considered. The analysis is then supplemented by inclusion of an additional index specifically developed for this report. Unlike the other indices, this one utilizes relationships derived from the 1972 input-output table of the United States (Reference 2).

D. The 496 industry/commodity level Bureau of Economic Analysis (BEA) study is a general equilibrium model proposed by Wassily Leontief which attempts to represent the economic structure of the United States. This report concentrates on the aircraft and parts industry and uses the information within that industry to construct a SIC R&D index.

E. To summarize briefly, this report:

1. Appraises how well BEA and OSD indices reflect actual price movements within the Research, Development, Test and Evaluation (RDT&E) program for US Army Aviation.

2. Assesses the reliability of the data used by BEA, DARCOM and OSD based on a comparison with the Consumer Price Index (CPI), the Producer Price Index (PPI) and the Implicit Price Deflator (IPD). This data is also examined with regard to the index constructed using the 1972 input-output table of the US Economy.

3. Considers the forecasting value of each index as it relates to commodities that are familiar to Army Aviation Research and Development.

II. INTRODUCTION.

A. An index is a ratio used to measure some kind of relative change over a given period of time, space, or other choice variable. Indices are used extensively in both private and public sectors. There are indices for income, indices for output, indices for manhours employed, etc. There are indices for all types of variables whose selection is restricted only by the condition that the variables are somehow quantifiable. The index most commonly known to us all is the widely used Consumer Price Index (CPI). The CPI is a price index that is often used as a management tool and as a means of condensing information. We are most familiar with its use as a yardstick for judging the economic well being of various individual groups in terms of changes in the cost of living.

B. The CPI is only one type of price index. Other price indices are the Producer Price Index (PPI), the Implicit Price Deflator (IPD) and all the many subindices that are frequently constructed to measure price changes within the various individual commodity groups. Oftentimes, an individual or agency will construct a special index to suit its own particular needs. These indices are sometimes constructed from raw data and at other times constructed by weighting two or more already published indices. Thus, one can easily infer that indices are not only very helpful, but also quite abundant.[1/]

C. The Army makes extensive use of price indices. With the modern advanced systems that are being developed, price indices with respect to cost can be an invaluable tool in measuring the cost growth and cost-effectiveness of such systems. Furthermore, and perhaps most importantly,

FOOTNOTE: 1. Fisher listed by name and illustrated by formula some twenty three pages of indices and their variants. He calls the first ninety nine indices (1-99) Primary Formulae.

price indices are the means by which the Army maintains the real terms of its contracts with private industry.

D. The most commonly employed price indices are the Laspeyres and Paasche type of indices. Both are relatively easy to calculate and each adequately satisfies the criterion set forth to assess the qualities one would like to have in an index. Neither satisfies all the criterion generally found desirable for an index, but for most purposes they have proven to be very effective tools. The properties associated with indices of primary interest in the report are: the time reversal test and the factor reversal test. (Fisher (Reference 3) called these the two great reversal tests.)

E. The time reversal property merely states that if two periods, say year Ø and year 10 are interchanged, then the corresponding indices are reciprocals of each other.

F. The factor reversal property states that the index multiplied by the same index but with the price and quantity notations switched equals the total value of all commodities in the given period divided by the total value of all commodities in the base period.

G. The "Ideal" price index satisfies both the time reversal property and the factor reversal property. The Laspeyres and Paasche indices do not. However, the "Ideal" index is more difficult to calculate and, consequently, is less frequently employed. Appendix A contains the mathematical formulation of the Ideal index in order to demonstrate its relationship to the Laspeyres and Paasche indices. This appendix also contains illustrations of some lesser known price indices.

III. AVIATION PRICE INDICES.

A. Table 1 lists the nineteen indices of foremost interest in the discussions that follow. The AVRADCOM Research and Development (R&D) indices shown in columns 1 through 4 and column A are Laspeyres type of price indices. This means that the weights used in their construction are the base period quantities. Weights, of course, are the means by which the relative importance of commodities is accounted for in our attempt to accurately aggregate commodities into a single price index. BEA indices (columns 13 and 14) and OSD indices (columns 11 and 12) are Paasche type indices and, thus, use current period quantities as their weights. The remaining indices are also Laspeyres type indices.

B. The fundamental distinction between a Paasche and Laspeyres index, as was just pointed out, is that the former index weights the individual price change of a component commodity with current period quantities purchased and the latter index uses base period quantities purchased. The difference in methodology is significant. If taste and quality changes are ignored, the most common response to a comparison of Laspeyres to Paasche indices usually cites the following statement as valid:

> Fixed weight (Laspeyres) indices generally overstate the magnitude of price changes during times of inflation while current period weighted (Paasche) indices generally understate them.

C. Not everyone agrees with the above statement. Fisher and Shell (Reference 5) show that the above relationships are tenuous if one allows taste to change; while Lamm (Reference 6) attempts to show that the statement is completely erroneous. Lamm argues that the results sought from a price index, whether Laspeyres or Paasche, is always the same -- a measurement of a price change.

D. Lamm's point, however, is not very well taken. The aggregative indices such as the Paasche and Laspeyres indices are constructed in order to measure the true impact of price changes on the purchaser. Moreover, Lamm's results are not very robust due to the fact that his data is confined to relatively inelastic food items. Lamm's argument would hold if there is only one good considered. One would merely calculate the price in the current year over the price charged in the base year, deriving what is called the simple price relative. However, in aggregating over commodity groups one implicitly assigns, through following this same procedure, i.e., $\sum (p_1/po)$, the highest weight to the item which ne largest absolute price change. This would no doubt bias an Army aviation R&D index in favor of the more expensive exotic material even if a less expensive material was a large part of the program. And, of course, the objective is to either determine how much it would cost today to purchase the same mix of items as purchased in the base period or how much it costs to buy a certain mix of goods today in relation to how much it would have cost to buy the same mix of goods in the base period.

E. In this report, the topic of whether or not the Laspeyres index generally overstates inflation and the Paasche index generally understates inflation is explored in the context of finding a suitable R&D index for Army aviation.

F. Given a price change in Army aviation R&D, it is difficult to make an a priori assessment of the degree of substitution among inputs that may take place. Conceptually, unlimited opportunities for substitution exists both on the part of the Government and for government contractors. However, due to technological and time constraints and the urgent (inelastic) requirement for Army aviation research and development, many potential substitutions will

not be made. Living in an environment of this type, then, invites the use of the Laspeyres index rather than the Paasche index. A Laspeyres index measures the change in prices per se; that is, the user assumes an inelastic demand schedule. A Paasche index, on the other hand, measures the change in cost after management reacts to a change in relative prices. As a result, a Laspeyres index should be higher than a Paasche index for the same commodity group in research and development, ceteris paribus. Furthermore, because quality in the early stages of the production process (e.g., production of aluminum, monel on steel sheets) is relatively stable, the difference between a Laspeyres index and a Paasche index for research and development stems largely from the substitution effect.

G. A close inspection of the table of indices (Table 1) details some surprising results in light of the discussion above. It is interesting to find that almost invariably,the BEA (Paasche) indices reflect higher inflation rates than either the OSD or DARCOM (Laspeyres) indices. This suggests that the BEA indices measure something quite apart from the DARCOM and OSD indices. One explanation to account for this result points to the inclusion of government labor in the construction of DARCOM indices. Also, unlike the DARCOM OSD indices, the BEA indices include all services, not just the Army. It is likely that the BEA indices are pushed upward by measuring across services; thus capturing the escalation of commodities not used by the Army. Government labor has a significant weight in R&D (34%) and it has experienced less escalation than found in contractor labor; and, even less yet, than that found in material cost. The BEA, OSD and DARCOM indices for 1974 (the earliest year available that includes data for all the indices) are 1.849, 1.704 and 1.7665, respectively. If government labor is removed

from the DARCOM index, the DARCOM index increases from 1.7665 to 1.9104.

H. It should be noted that DARCOM's indices are more in agreement with the general price level and the price changes as measured by the CPI, PPI and Implicit Price Deflator (IPD). The OSD and BEA indices do not compare quite as well. The OSD index, for example, does not report in its aircraft procurement index the large increase in costs during 1974 as generally reported; but, rather, the OSD inflation rate declines from 7.3 percent in 1973 to 6.8 percent in 1974!

I. Up tothis point, only those indices which have been constructed prior to this report have been reviewed. Nonetheless, it surely would be to the advantage of AVRADCOM to continue working for more accurate and reliable indices. The SIC R&D index detailed below is one such effort to achieve a more reliable R&D index.

J. Basically, the SIC R&D index is a more comprehensive AVRADCOM R&D index than constructed to date. It contains the same inputs as the AVRADCOM R&D index plus what might be termed an overhead component. Looking at Appendix B, the inputs to the Aircraft and Parts industry list three cost elements that were not explicitly accounted for in the earlier indices. These are Eating and Drinking Places, Lodging and Miscellaneous Business and Professional Services. All the rest of the commodity inputs listed in Appendix C were considered. Viewing the above inputs as overnead, one can appreciate their importance. Miscellaneous Business Services ranks as the seventh (7th) largest input to the Aircraft and Parts industry; Eating and Drinking Places ranks eighth (8th), and Lodging ranks twelfth (12th). Together, these elements represent almost 25 percent of the total intermediate inputs employed in the Aircraft and Parts industry.

K. Comparing the SIC R&D index with the indices given in table 1, some interesting observations can be made. With respect to the indices shown in columns 1 through 4 (the USAAVRADCOM indices), the SIC R&D index is substantially larger in every year except in 1976 under category 6.4. The reason for this lies in the construction of the SIC R&D index's labor and material weights; for as you may recall, the only difference between the SIC R&D index and the USAAVRADCOM indices is that an overhead component was included in the former index based upon the 1972 input output table for the United States. Incorporated into the SIC R&D index during its construction was appreciably greater weight for material and overhead components relative to labor. This alone increased the value of the index. In fact, the weights for labor and material for the SIC R&D index shown in table 1 are nearly equal. This may explain, then, the close relationship between the SIC R&D index and the Engine Production price index in column 6 of table 1. In both cases material is weighted much greater than in the other R&D price indices (columns 1 through 4).

L. Looking at table 2, one can see the effect on the SIC R&D index as labor is weighted less and materials weighted more. For categories 6.1/6.2, price increases are significantly lower than either 6.3 or 6.4 categories. Again, this is largely, if not solely, due to the assigned weights. The 6.1/6.2 category has a greater percentage of its input comprised of labor than does either the 6.3 or 6.4 categories. The 6.3 category, in turn, is more labor intensive than the 6.4 category.

IV. SUMMARY.

A. Indices are an integral part of cost tracking defense projects. It is generally acknowledged that the success of a program depends on the way the resources are allocated in real terms and that little can be done to avoid inflationary impacts given current institutional arrangements.

B. The purpose of this report is to compare various indices commonly used to measure inflation and analyze their relative effectiveness in reflecting actual price movements. Some reliability problems are surfaced, especially for the OSD index.

C. After some theoretical discussion, an index is proposed that incorporates Input-Output Analysis. Called the SIC R&D Index, this index accounts for costs other than labor and material. These costs are collected under the name overhead, although indirect costs are also included. The behavior of the SIC R&D Index is examined and found to behave as expected with respect to other indices.

V. FURTHER RESEARCH.

A. The central issue reported here concerns the choice of index for Army aviation systems. The bulk of the indices discussed are either Laspeyres or Paasche type (both termed aggregative); albeit, it may be fruitful to construct certain other types of indices, namely, the geometric, the arithmetic, the median, and the mode, or else expand upon the aggregative indices to include, say, Fisher's Ideal Index.

B. In addition, an analysis could be presented which describes the various indices in terms of their relative errors as delineated by:

1. The choice of formula.
2. The items included.
3. The number of items included.
4. The proportion of data that is primary rather than secondary.

These errors are, in general, relatively small for most commodities. Nevertheless, this may not hold strictly true for the exotic material demanded by Army aircraft systems and, so, we really should consider them at some point in time.

C. Another promising research area that should be given serious attention is that effort already being carried out by others; that is, to adjust the indices presently being calculated for quality changes. Ignoring quality change usually leads to understated indices. For example, the cost of top of the line video cassette recorders has increased somewhat but quality has increased markedly. Methods which ignore quality changes would result in measured inflation when, in fact, it is likely that the cost of services provided has decreased. Zvi Gilliches has estimated the influence of such quality change on prices within the automobile industry. Future research should extend this work using helicopter data. As a result, presently reported indices would be analyzed as to how much of a given year to year

increase is due to quality improvements.

D. The issue of quality changes could be examined at several levels, each leading perhaps to distinct conclusions. A consideration of quality changes in processed material inputs (e.g., steel sheet) would probably reduce the computed value of indices. A consideration of quality changes in the end-item (helicopter) would not lead to reduced indices but might lead to the conclusion that we are obtaining more combat effectiveness, air evacuation services, etc., per dollar expended than in the past. Quality changes for secondary items have some aspects of the two cases considered above.

E. A more fundamental issue which, to date, has not been completely or satisfactorily explored deals with the identification of inflation within the aircraft industry versus the cost increases that stem from the "ordinary conduct of business." Inflation is usually defined as a sustained increase in the general price level. In a two sector economy, it is the average change of two average prices, the average price increase (decrease) in sector one and the average price increase (decrease) in sector two. Supposing the price increase in sector two is always greater than the price increase in sector one (and recalling that the average will fall somewhere in-between), it is easy to see that only a part of the actual change in cost for sector two will be attributed to inflation. Now, should this be so? Granted costs (hence, prices) do increase for reasons other than inflation. For example, location theory tells us that some industries are tied to certain geographical areas where given, say, an exogenous increase in demand a premium must be paid to attract qualified labor. Or it may just be plain and simple management mistakes that account for a cost increase. In either case, these costs should not be included as part of the

inflation estimate. On the other hand, it may be that almost all of the increases in prices do stem from inflationary forces; either way, though, presently employed methods will contain some degree of error. Research should look at the aircraft industry and determine how great these errors are under the present methods of calculating inflation. To accomplish such a task, it will require a methodology that can somehow separate price increases due to inflation and price increases due to the "ordinary conduct of business!"

F. Economy-wide inflation is clearly an element of inflation for Army aircraft systems and an additional price change for inputs to the aircraft industry may also be appropriately included in inflation indices for Army aircraft systems. However, additional increases restricted to a particular Army aircraft system are certainly not inflation; they are real cost growth.

TABLE 1

SELECTED PRICE INDICES

FISCAL YEAR	(1) EXPL DEV 6.1/6.2	(2) ADV DEV 6.3	(3) ENG DEV 6.4	(4) OTHER R&D	(5) AIRFRAME PRODUCTION	(6) ENGINE PRODUCTION	(7) AVIONICS PRODUCTION	(8) CONSUMER PRICE INDEX CPI	(9) PRODUCER PRICE INDEX PPI	(10) IMPLICIT PRICE DEFLATOR IPD
69	100 (05.6)	100 (05.4)	100 (05.2)	100 (04.8)	100 (05.3)	100 (04.5)	100 (04.1)	100 (05.4)	100 (03.9)	100 (05.1)
70	108 (08.5)	109 (08.6)	109 (08.7)	109 (08.8)	105 (06.1)	109 (09.5)	105 (05.2)	106 (05.9)	104 (03.7)	105 (05.4)
71	115 (06.3)	116 (06.2)	116 (06.2)	115 (06.0)	112 (05.1)	115 (06.2)	109 (04.2)	111 (04.3)	107 (03.3)	110 (05.0)
72	121 (05.6)	122 (05.4)	122 (05.2)	121 (04.9)	117 (04.1)	117 (01.0)	112 (02.1)	114 (03.3)	112 (04.5)	115 (04.2)
73	128 (05.6)	128 (05.3)	128 (05.1)	127 (04.7)	122 (07.1)	122 (04.4)	115 (03.3)	121 (06.2)	121 (07.4)	121 (05.7)
74	136 (06.0)	137 (06.3)	137 (06.6)	136 (07.2)	131 (08.2)	132 (08.5)	121 (05.1)	134 (10.9)	139 (15.3)	132 (08.7)
75	147 (08.3)	149 (09.6)	151 (10.9)	154 (13.5)	141 (13.8)	160 (21.0)	133 (09.6)	146 (09.1)	154 (10.8)	144 (09.3)
76	156 (06.3)	159 (06.3)	161 (06.3)	164 (06.2)	161 (08.9)	170 (05.9)	140 (05.3)	155 (05.7)	161 (04.4)	152 (05.2)
77	169 (08.3)	173 (08.7)	175 (09.2)	180 (10.0)	175 (09.0)	189 (11.4)	152 (08.3)	165 (06.4)	171 (06.5)	161 (05.8)
78	182 (08.0)	187 (08.1)	190 (08.2)	195 (08.3)	183 (07.3)	201 (06.5)	169 (11.3)	177 (07.7)	185 (07.8)	172 (07.3)
79	196 (07.4)	202 (08.0)	206 (08.5)	214 (09.7)	226 (10.3)	220 (09.4)	187 (10.8)	197 (11.3)	205 (11.1)	187 (08.5)
80	213 (09.0)	221 (09.3)	225 (09.6)	236 (10.2)	257 (13.6)	253 (15.1)	211 (13.1)	224 (13.5)	233 (13.5)	204 (09.0)

TABLE 1 (CON'T)
SELECTED PRICE INDICES

FISCAL YEAR	(11) OSD R&D	(12) OSD AIRCRAFT PROCUREMENT	(13) BEA R&D	(14) BEA AIRCRAFT PROCUREMENT	(15) STAINLESS STEEL	(16) TITANIUM	(17) NOMEX	(18) ALUMINUM	(19) SIC R&D
74	100 (08.8)	100 (07.3)	100 (03.0)	100 (-2.1)	100 (11.6)	100 (07.6)	100 (13.4)	100 (10.0)	100 (08.7)
75	109 (09.0)	107 (06.8)	116 (15.6)	101 (01.3)	130 (29.5)	134 (34.4)	137 (37.1)	131 (31.3)	118.7(18.7)
76	115 (06.0)	115 (07.2)	128 (10.7)	114 (13.2)	122 (-5.6)	149 (10.6)	142 (03.3)	139 (06.0)	125.8(06.0)
77	123 (06.6)	126 (09.6)	143 (11.1)	128 (11.7)	144 (17.7)	148 (-.01)	142 (.01)	171 (22.8)	140.6 11.7
78	132 (07.4)	137 (08.8)	149 (04.6)	144 (13.0)	149 (03.6)	149 (.04)	139 (-2.4)	196 (15.0)	153.2 08.9
79	144 (08.7)	148 (08.6)	164 (09.7)	160 (10.6)	160 (07.4)	168 (13.6)	156 (12.5)	214 (09.1)	172.1(12.4)
80	156 (08.8)	160 (07.8)	180 (10.1)	176 (10.5)	173 (07.7)	234 (38.7)	184 (17.6)	215 (.02)	192.6(11.9)

Note: Figures in parenthesis represent rates of change and may vary from indices due to rounding.

TABLE 2

ARMY RESEARCH AND DEVELOPMENT PRICE INDICES

	6.1/6.2	6.3	6.4
1968	2.2881	2.3399	2.3918
1969	2.1664	2.2196	2.2728
1970	1.9990	2.0464	2.0938
1971	1.8829	1.9288	1.9748
1972	1.7861	1.8326	1.8791
1973	1.6887	1.7369	1.7850
1974	1.5874	1.6277	1.6680
1975	1.4644	1.4833	1.5021
1976	1.3781	1.3962	1.4143
1977	1.2733	1.2849	1.2964
1978	1.1787	1.1881	1.1975
1979	1.0949	1.0978	1.1007
1980	1.0000	1.0000	1.0000

REFERENCES

1. Letter, HQ, DARCOM, DRCCP-ER, 14 August 1981, subject: DARCOM Historical Inflation Review.

2. US Department of Commerce, The Detailed Input-Output Strucure of the U.S. Economy: 1972, Volume I and II, 1979.

3. Irving Fischer, The Making of Index Numbers, Houghton Mifflin Company, New York, NY, 1922.

4. Zvi Griliches, ed., Price Indexes and Quality Change, Studies in New Methods of Measurement, Harvard University Press, Mass., 1971.

5. R. Lamm, Index Numbers and Changes in Food Prices, Agricultural Economics Research, April 1980.

6. Letter, HQ, DARCOM, DRCCP-ER, March 1981, subject: Use of Inflation Indices in Cost Estimates.

BIBLIOGRAPHY

1. Bureau of Labor Statistics Handbook of Methods, Washington DC: US Department of Labor, Bureau of Labor Statistics, 1966.

2. Braithwait, S. D., "The Substitution Bias of the Laspeyres Price Index," American Economic Review, March 1980.

3. Lines, Charles W. Jr., Research Report: Historical Research and Development Inflation Indices for Army Fixed and Rotor Winged Aircraft, St. Louis, MO: US Army Aviation Research and Development Command, January 1981.

4. Fisher, Irving, The Making of Index Numbers, Houghton Mifflin Company, New York, 1922.

5. Griliches, Zvi, Editor, Price Indexes and Quality Change, Studies in New Methods of Measurement, Harvard University Press, Mass., 1971.

6. Stigler, G., and J. Kindahl, The Behavior of Industrial Prices, NBER, New York, 1970.

7. Addendum to the Remotely Piloted Vehicle (RPV) Baseline Cost Estimate (BCE)/Independent Cost Estimate (ICE), St. Louis, MO: US Army Aviation Research and Development Command, February 1981.

8. US Department of Labor CPI Detailed Report, Washington, DC, September 1981.

9. Wallace, William H., and William E. Cullison, Measuring Price Changes: A Study of Price Indexes, Federal Reserve Bank of Richmond, November 1976.

10. Memorandum on DARCOM Historical Inflation Review, Zimmerman, Denise C., Washington, DC: Department of the Army, 14 August 1981.

APPENDIX A

Algebraic Presentation of Different Index Types

The Laspeyres Index is formulated as

$$L_{01} = \Sigma p_1 q_0 / \Sigma p_0 q_0 \qquad \text{where}$$

p is the price in the period designated by the subscript and

q is the quantity purchased in the period designated by its subscript.

It can be seen that a comparison of any two periods is legitimate because

$$L_{12} = \Sigma p_2 q_0 / \Sigma p_0 q_0 \div \Sigma p_1 q_0 / \Sigma p_0 q_0$$

$$L_{12} = \Sigma p_2 q_0 / \Sigma p_0 q_0 \cdot \Sigma p_0 q_0 / \Sigma p_1 q_0 = \frac{\Sigma p_2 q_0}{\Sigma p_1 q_0} .$$

The Paasche Index, on the other hand, is written

$P_{01} = \Sigma p_1 q_1 / \Sigma p_0 q_1$. Thus, for any two different periods, we have

$$P_{12} = \Sigma p_2 q_2 / \Sigma p_0 q_2 \div \Sigma p_1 q_1 / \Sigma p_0 q_1$$

$P_{12} = \Sigma p_2 q_2 / \Sigma p_0 q_2 \cdot \Sigma p_0 q_1 / \Sigma p_1 q_1$. Here, unlike with the Laspeyres Index, the terms do not cancel out and so the interpretation given to the result must vary from the one given to the Laspeyres Index.

Fisher's Ideal Index is a geometric average of the Paasche and Laspeyres indexes and may be written

$$F_{01} = (L_{01} P_{01})^{\frac{1}{2}}$$

$$= \left(\Sigma p_1 q_0 / \Sigma p_0 q_0 \cdot \frac{\Sigma p_1 q_1}{\Sigma p_0 q_1} \right)^{1/2}$$

Period to period changes are even more complicated than the Paasche Index. We have

$$F_{12} = \left(\Sigma p_1 q_0 / \Sigma p_0 q_0 \cdot \frac{\Sigma p_1 q_1}{\Sigma p_0 q_1} \cdot \frac{\Sigma p_0 q_0}{\Sigma p_2 q_0} \cdot \frac{\Sigma p_0 q_2}{\Sigma p_2 q_2} \right)^{1/2}$$

$$= \left(\Sigma p_1 q_0 \cdot \Sigma p_0 q_2 \;/\; \Sigma p_0 q_1 \; \Sigma p_2 q_0 \; \Sigma p_2 q_2 \right)^{\frac{1}{2}}$$

The weighted Average of Relatives Index is simply the ratio of prices weighted by total expenditures. To show that this is identical to the Laspeyres Index, we have

$$I_{01} = \Sigma \left[\frac{p_1}{p_0} \cdot p_0 q_0 \right] / \Sigma p_0 q_0 .$$ Cancelling the base prices in the numerator leaves,

$$I_{01} = \Sigma p_1 q_0 / \Sigma p_0 q_0$$ which is the familiar Laspeyres formula.

The Marshall-Edgeworth Index uses the arithmetic mean of the base year and given year quantities. Mathematically

$$\text{M-E Index} = \frac{\Sigma pm \; (q_0 + q_n)}{\Sigma p_0 \; (q_0 + q_n)}$$

While there are many different indices, perhaps, the simplest index is the price relative.

$$\text{Price relative} = p_n / p_0 \quad .$$

Other indices and their formula include

a. Palgrave index = $$\frac{\Sigma p_1 q_1 \; \frac{p_1}{p_o}}{\Sigma p_1 q_1}$$

APPENDIX A (Continued)

b. FRB Index $= \sqrt[\Sigma p_1 q_1]{\left(\frac{p_1}{p_0}\right)^{p_1 q_1} \left(\frac{p_1'}{p_0'}\right)^{p_1' q_1'}}$

where ' represents a commodity different from other commodities in the formula.

c. BLS Index $= \dfrac{\Sigma p_0 q_0 \frac{p_1}{p_0}}{\Sigma p_0 q_0}$

APPENDIX B

Transaction Matrix-Aircraft SIC 3721

Aircraft Inputs in Millions of US Dollars

I-O	Dollars	I-O	Dollars
2.0401	$ 700,000	24.0703	$ 500,000
2.0702	200,000	24.0705	100,000
3.0000	100,000	24.0706	300,000
4.0000	700,000	26.0200	800,000
7.0000	200,000	26.0301	700,000
*12.0201	26,800,000	26.0400	300,000
12.0216	4,200,000	*26.0501	8,200,000
13.0500	200,000	*26.0601	12,800,000
13.0700	1,000,000	26.0602	300,000
14.0101	1,100,000	26.0801	100,000
14.0102	900,000	27.0100	1,200,000
14.0103	900,000	27.0401	100,000
14.2001	1,300,000	27.0402	1,000,000
14.2103	1,900,000	*28.0100	15,400,000
14.2104	4,700,000	*30.0000	20,900,000
15.0101	2,100,000	*31.0100	22,400,000
15.0102	400,000	32.0100	4,200,000
*16.0100	8,100,000	32.0302	5,200,000
17.0100	5,300,000	32.0400	6,500,000
18.0400	3,800,000	34.0302	600,000
19,0306	300,000	34.0304	400,000
20.0200	2,600,000	34.0305	200,000
20.0903	100,000	35.0100	900.000
21.0000	500,000	36.0900	100,000
*23.0300	14,300,000	36.1600	200,000
24.0400	1,200,000	36.1800	200,000
24.0500	800,000	36.2200	3,600,000
24.0701	200,000	*37.0101	14,200,000
37.0200	4,600,000	49.0700	6,000,000
37.0300	4,700,000	50.0001	900,000
*37.0401	10,500,000	50.0002	176,100,000
38.0700	1,000,000	*51.0101	51,800,000
*38.0800	78,300,000	*53.0100	16,300,000
*38.0900	17,500,000	53.0400	2,400,000
*38.1000	12,000,000	54.0400	200,000
*38.1100	19,400,000	55.0100	500,000
38.1200	300,000	56.0100	2,100,000
38.1300	6,000,000	*56.0400	647,500,000
*38.1400	38,200,000	*57.0200	86,100,000
*41.0100	60.600,000	*57.0300	183,100,000
*41.0203	8,000,000	50.0100	300,000
42.0201	900,000	58.0300	800,000

APPENDIX E
Transaction Matrix-Aircraft SIC 3721
(Continued)

I-O	Dollars
42.0202	$ 1,000,000
*42.0300	43,300,000
*42.0401	19,200,000
*41.0402	23,600,000
42.0500	5,700,000
*42.0800	10,300,000
42.1100	17,500,000
47.0100	5,000,000
47.0200	1,500,000
*47.0300	35,300,000
47.0401	300,000
*49.0100	42,400,000
49.0200	4,900,000
64.0104	300,000
64.0400	1,200,000
64.0501	400,000
64.0502	100,000
64.0503	200,000
64.0504	1,700,000
64.1200	100,000
65.0100	6,800,000
*65.0200	32,300,000
*65.0300	42,700,000
65.0400	1,800,000
*65.0500	79,700,000
65.0600	100,000
65.0700	400,000
*66.0000	41,600,000
*68.0100	34,100,000
68.0200	6,600,000
68.0300	3,300,000
*69.0100	142,600,000
*69.0200	18,500,000
*70.0100	23,800,000
70.0200	4,200,000
*70.0300	10,000,000
*70.0400	8,900,000
*71.0200	53,500,000
*72.0100	74,800,000
*72.0200	23,400,000

I-O	Dollars
*58.0400	$29,700,000
59.0302	100,000
*60.0100	31,200,000
*60.0200	407,500,000
*60.0400	1,228,000,000
*62.0100	56,400,000
*62.0200	21,700,000
62.0500	2,700,000
*62.0700	15,500,000
*63.0100	42,700,000
63.0200	900,000
*63.0300	16,900,000
64.0101	400,000
*73.0100	164,700,000
*73.0200	18,700,000
*73.0300	107,400,000
*74.0000	240,000,000
*75.0000	19,500,000
76.0200	5,000,000
77.0400	800,000
*77.0500	12,200,000
77.0600	6,700,000
*78.0100	17,600,000
79.0300	200,000
*80.0000	18,100,000
81.0000	600,000

TII	$4,935,800,000
VA	$3,961,100,000
TIO	$8,896,900,000

VA is composed of:

1. Employee compensation.

2. Indirect business taxes.

3. Property-type income.

*Significant input

APPENDIX C

Major Inputs-Aircraft SIC 3721

Major Inputs Aircraft I-O 60-0100 SIC 3721

I-O	SIC	Description	Amount
12.0201	1500, 1700	Construction	$ 26,800,000
16.0100	2211	Broad Woven Fabric Mills, Cotton	8,100,000
23.0300	2531	Public Bldg and Related Furniture	14,300,000
26.0501	2751	Commercial Printing	8,200,000
26.0601	2761	Manifold Business Forms	12,800,000
28.0100	2821	Plastics Materials Synthetic Resins and Nonvolcanizable Elastomers	15,400,000
30.0000	2851	Paints, Varnishes, Lacquers, Enamels and Allied Prod.	20,900,000
31.0100	2911	Petroleum Refining	22,400,000
37.0101	3312	Blast Furnaces, Steel Works, and Rolling and Furnishing Mills	14,200,000
37.0401	3398	Metal Heat Treating	10,500,000
38.0800	3355	Aluminum Rolling and Drawing WEC	78,300,000
38.0900	3356	Rolling, Drawing and Extending of Nonferrous Metals, Exempt Copper and Aluminum	17,500,000
38.1000	3357	Drawing and Insulating of Nonferrous Wire	12,000,000
38.1100	3361	Aluminum Foundries (Casting)	19,400,000
38.1400	3463	Nonferrous Forgings	38,200,000
41.0100	345	Screw Machine Prod, and Bolts, Nuts Screws Rivets, and Washers	60,600,000
41.0203	3469	Metal Stampings NEC	8,000,000
42.0300	3429	Hardware NEC	43,300,000
42.0401	3471	Cutlery	19,200,000
42.0402	3479	Metal Casting and Allied Services	23,600,000
42.0800	3494	Valves and Pipe Vittings, Except Plumber's Brass Coals	
47.0300	3544	Special Dies and Tools, Die Sets, Jigs and Fixtures and Industrial Molds	35,300,000
49.0100	3561	Pumps and Pumping Equipment Air and Gas Compressors	42,400,000
50.0002	3599	Machinery Except Electrical Nec	172,100,000
51.0101	3573	Electronic Computing Equipment	54,800,000
53.0100	3825	Instruments to Measure Electricity	16,300,000
56.0400	3662	Radio and TV Communication Equipment	647,500,000
57.0200	3674	Semiconductors and Related Devices	86,100,000
57.0300	3675	Electronic Components Nec.	183,100,000
58.0400	3694	Engine Elect ical Equipment	29,700,000
60.0100	3721	Aircraft	31,200,000
60,0200	3724	Aircraft and Missile Engine & Engine Parts	407,500,000
60.0400	3728	Aircraft and Missile Equipment Nec.	1,228,000,000

APPENDIX C

Major Inputs-Aircraft SIC 3721

(Continued)

I-O	SIC	Description	Amount
62.0100	3811	Engineering and Scientific Instruments	$ 56,400,000
62.0200	3823	Mechanical Measuring Devices	21,700,000
62.0700	387	Watches, Clock, Clockwork Operated Devices	15,500,000
63.0100	383	Optical Instruments and Lenses	42,700,000
63.0300	386	Photographic Equipment and Supplies	16,900,000
65.0200	411	Local and Suburban Passenger Transportation	32,300,000
65.0300	42	Motor Freight Transp. and Warehousing	42,700,000
65.0500	45	Air Transportation	79,700,000
66.0000	48	Communication (except radio and TV)	41,600,000
68.0100	491	Electric Services (utilities)	34,100,000
69.0100	50 and 51	Wholesale Trade	142,600,000
69.0200	51, 57, and 59	Retail Trade	18,500,000
70.0100	60	Banking	23,800,000
70.0300	62	Security and Commodity Brokers	10,000,000
70.0400	63	Insurance Carriers	8,900,000
71.0200	65	Real Estate	53,500,000
72.0100	70	Hotels and Lodging	74,800,000
72.0200	72	Personal and Repair Services Except Auto Repair, Beauty and Barber Shops	23,400,000
73.0100	732-7329	Misc. Business Services	164,700,000
73.0200	731	Advertising	18,700,000
73.0300	81, 89	Misc. Professional Services	107,400,000
74.0000	58	Eating and Drinking Places	240,000,000
75.0000	75	Automobile Repair and Services	19,500,000
77.0500	84, 8922	Nonprofit Organizations	12,200,000
78.0100	4311	U.S. Postal Services	17,600,000
80.0000		Noncomparable Imports	18,100,000

APPENDIX C
Major Inputs-Aircraft SIC 3721
(Continued)

Nine digit figures or more:

73.0100	Miscellaneous Business Services	$ 164,700,100
50.0002	Machinery, except electrical, n.e.c.	176,100,000
56.0400	Radio and TV communication equipment	647,500,000
57.0300	Electronic components n.e.c.	183,100,000
60.0200	Aircraft and missile engines and parts	407,500,000
60.0400	Aircraft and missile equipment necessary	1,228,000,000
69.0100	Wholesale trade	142,600,000
73.0300	Miscellaneous professional services	107,400,000
74.0000	Eating and drinking places	240,000,000
	Total	$3,296,900,000

These commodities make up 67% of the total inputs excluding labor and 37% of the total industry output.

APPENDIX D

Aircraft and Missiles Engine and Engine Parts
60.02

60.0200 Six digits or more Aircraft and Missiles Engines and Engine Parts

1-0

12.0201	$16,600,000	T11	$2,273,500,000
31.0100	19,500,000	VA	$1,943,700,000
37.0101	119,400,000		
*37.0200	48,300,000	T10	$4,217,200,000
*37.0300	83,800,000		
38.0900	26,000,000		
38.1100	36,300,000		
*38.1300	98,000,000		
38.1400	59,900,000		
41.0100	16,000,000		
42.0401	23,200,000		
47.0300	58,100,000		
*49,0200	14,200,000		
50.0002	91,900,000		
56.0400	13,800,000		
57.0300	10,300,000		
58.0400	23,900,000		
60.0200	637,600,000		
60.0400	134,800,000		
62.0200	28,300,000		
65.0300	14,400,000		
65.0500	11,700,000		
66.0000	22,500,000		
68.0100	31,000,000		
69.0100	65,400,000		
70.0100	11,800,000		
71.0200	16,500,000		
72.0200	11,000,000		
73.0100	91,300,000		
73.0300	60,800,000		
74.0000	135,600,000		
78.0100	11,400,000		
80.0000	10,300,000		
*81.000	10,700,000		

*Not included as a major input under 60.0100 Aircraft.

APPENDIX E

Major Inputs - Aircraft and Missile Equipment, n.e.c.

60.04

60.0400 Nine digits or more Aircraft and Missile Equipment n.e.c.

60.0400	Aircraft and Missile Equipment, n.e.c.	$371,500,000
74.0000	Eating and Drinking Places	$112,000,000

60.0400 Six digits or more

12.0201	$ 10,600,000	T11	$1,976,500,000
28.0100	15,500,000	VA	$1,945,500,000
31.0100	17,900,000	T10	$3,922,000,000
37.0101	59,200,000		
*37.0200	21,700,000		
*37.0300	38,400,000		
38.0800	72,900,000		
38.0900	25,000,000		
38.1100	22,800,000		
*38.1300	12,700,000		
38.1400	24,100,000		
41.0100	38,900,000		
41.0203	14,700,000		
42.0300	10,700,000		
42.0401	23,200,000		
47.0300	42,400,000		
49.0700	15,800,000		
50.0002	65,200,000		
56.0400	94,800,000		
57.0200	94,900,000		
57.0300	61,600,000		
60.0200	46,300,000		
60.0400	371,500,000		
65.0200	22,800,000		
65.0300	12,000,000		
65.0500	32,300,000		
66.0000	22,200,000		
68.0100	28,800,000		
69.0100	69,000,000		
70.0100	10,300,000		
71.0200	35,100,000		
72.0100	42,100,000		
72.0200	13,800,000		
73.0100	83,000,000		
73.0300	50,300,000		
74.0000	112,000,000		

*Not a major input under 60.100 Aircraft.

APPENDIX F

Major Inputs - Aircraft

60.01-60.04

I-O		
60.0400	Machinery except electrical n.e.c.	$1,228,000,000
56.0400	Radio and TV communication equipment	647,500,000
60.0200	Aircraft and missile engine and engine parts	407,500,000
74.0000	Eating and Drinking Places	240,000,000
57.0300	Electronic components, n.e.c.	183,100,000
50.0002	Machinery, except electrical, n.e.c.	176,100,000
73.0100	Miscellaneous Business Services	164,700,000
69.0100	Wholesale trade	142,600,000
73.0300	Miscellaneous professional services	107,400,000
57.0200	Semiconductors and related devices	86,100,000
65.0500	Air Transportation	79,700,000
38.0800	Aluminum rolling and drawing, n.e.c.	78,300,000
72.0100	Hotels and lodging places	74,800,000
41.0100	Screw machine prod. and related products	60,600,000
62.0100	Engineering and scientific equipment	56,400,000

NOTE: The above commodities represent 75% of the total inputs excluding labor and 42% of the total industry output.

APPENDIX G

Industries Important to Aircraft Production Designated by SIC Codes

3355	Aluminum Rolling and Drawing NEC
345X	Screw Machine Products and Bolts, Nuts, Screws, Rivets, and Washers
3599	Machinery, Except Electrical, NEC
3662	Radio and TV Transmitting Signaling, and Detection Equipment and Apparatus
3674	Semiconductors and Related Devices
3675	Electronic Capacitors
3724	Aircraft Engines and Engine Parts
3728	Aircraft Parts and Auxiliary Equipment, NEC
3811	Engineering and Scientific Instruments
45XX	Transportation by Air
50XX,51XX	Wholesale Trade
58XX	Eating and Drinking Places
70XX	Lodging Places
732X-7329	Miscellaneous Business Services

*332X	Iron and Steel Foundries
*3462	Metal Forgings and Stampings
*3369	Nonferrous Foundries (Castings) NEC

NOTE: *These last three industries are not significant for 3721 Aircraft and Parts, but are important as inputs to 3724 Aircraft Engines and Engine Parts, and 3728 Aircraft Parts and Auxiliary Equipment, NEC.

APPENDIX B

Methods to Compare Indices

There are numerous ways in which to compare different indices of the same type. One way is to look at each index's percentage change from year to year over a common time frame and note the differences between them. This gives one a general view of how well one index conforms to the other and vice versa. This is basically the method taken in the body of this report.

Another feature one might want to consider (other than comparability with other indices) is the dispersion within the index. One such measure of the dispersion within an index was suggested by Messrs. George Stigler and James Kendahl. The formula is

$$\frac{1}{T}\sum_{i=1}^{T}\sqrt{\frac{\sum_{j=1}^{N_i}\left(P_{i,j}/P_{i-1,j} - I_i/I_{i-1}\right)^2}{N_i - 1}}$$

where: $P_{i,j}$ is the price of commodity in month i

N_i is the number of commodities reporting in month i and i-1

T is the number of months

I_i is the index for month i.

The result, of course, is the standard deviation of movements of individual prices about the index, I. No calculations are presented here on the indices discussed within this report due to the limited number of observations. The most appealing hypothesis concerning the dispersion

within the aggregate index is that for any aviation index the spread is quite large. But, the cause lies on the choice of the commodities themselves and not in the construction of the index.

A times series analysis could be undertaken to answer questions regarding the trend component, the cyclical component, and the random behavior of the indices. Again, no attempt was made to model the indices calculated for this report. Suffice to note that Stigler and Kendahl used the formula:

$$\sigma^2 = \sum (X_t - \bar{X})^2 / N-1$$

where $X_t = \ln I_t - \ln I_{t-1}$,

to measure volatility and included that in a regression equation in order to explain price fluctuations.

APPENDIX 1
Calculation of SIC R&D Index

Step 1

Find percent of total intermediate outputs, the following SIC categories (use 1972 I-O table):

1. Eating and Drinking Places.

2. Business services.

3. Hotels and lodging, personal and repair services (except auto).

60.01 Aircraft has TIO equal to $8,896,900,000
60.02 Aircraft and missile engine and engine parts has TIO equal to $4,217,200,000.
60.04 Aircraft and missile equipment, n.e.c. has TIO equal to $3,922,000,000

Thus, TIO for I-O 60.0000 is $17,036,100,000

Eating and Drinking Places for Aircraft Industry I-O 60.0000 is

I-O 74.0000

60.01	$240,000,000
60.02	135,600,000
60.04	112,000,000
	Σ $487,600,000

$$\frac{\$487,600,000}{\$17,036,100,000} = 2.86\%$$

Business Services I-O 73.0100 and 73.0300

60.01 [$164,700,000 + 107,400,000] = $272,100,000

60.02 [$91,300,000 + 60,800,000] = $152,100,000

60.04 [$83,000,000 + 50,300,000] = $133,300,000

Σ$557,500,000

$$\frac{\$557,500,000}{\$17,036,100,000} = 3.27\%$$

Hotel and lodging, personal and repair services except auto for aircraft 60.0000

60.01 $74,800,000

60.02 Not significant

60.04 $42,000,000

Σ $116,900,000

$$\frac{\$116,900,000}{\$17,036,100,000} = .69\%$$

The sum of the overhead represents

[2.86 + 3.27 + .69] = 6.82 percent of the total output of

the aircraft industry.

Step 2

Gather data for Consumer Price Index (CPI) by Selected Items.

	Food and Beverages	Rent (Incl lodging while away)	All Services
1968	103.6	102.4	105.2
69	108.8	105.7	112.5
70	114.7	110.1	121.6
71	118.3	115.2	128.4
72	123.2	119.2	133.3
73	139.5	124.3	139.1
74	158.7	130.6	152.1
75	172.1	137.3	166.6
76	177.4	144.7	180.4
77	188.0	153.5	194.3
78	206.3	164.0	210.9
79	228.5	176.0	234.2
80	262.6	199.6	270.3
81	271.4	209.9	316.9

Step 3

Weight each CPI sub-index by percent of total intermediate outputs found in Step 1.

$$2.86 + 3.27 + .69 = 6.82$$

	Eating & Drinking		Hotel & Lodging		Business Services	
1968	103.6 X	$\left({}^{2.86}/_{6.82} \right)$	+ 102.4 X	$\left({}^{.69}/_{6.82} \right)$	+ 105.2 X	$\left({}^{3.27}/_{6.82} \right)$
69	108.8 X	"	+ 105.7 X	"	+ 112.5 X	"
70	114.7 X	"	+ 110.1 X	"	+ 121.6 X	"
71	118.3 X	"	+ 115.2 X	"	+ 128.4 X	"
72	123.2 X	"	+ 119.2 X	"	+ 133.3 X	"
73	139.5 X	"	+ 124.3 X	"	+ 139.1 X	"
74	158.7 X	"	+ 130.6 X	"	+ 152.1 X	"
75	172.1 X	"	+ 137.3 X	"	+ 166.6 X	"
76	177.4 X	"	+ 144.7 X	"	+ 180.4 X	"
77	188.0 X	"	+ 153.5 X	"	+ 194.3 X	"
78	206.3 X	"	+ 164.0 X	"	+ 210.9 X	"
79	228.5 X	"	+ 176.0 X	"	+ 234.2 X	"
80	262.6 X	"	+ 199.6 X	"	+ 270.3 X	"
81	271.4 X	"	+ 209.9 X	"	+ 316.9 X	"

$${}^{2.86}/_{6.82} = 41.95\%$$

$${}^{.69}/_{6.82} = 10.12$$

$${}^{3.27}/_{6.82} = 47.95$$

Step 4

Sum the indices for new overhead index.

			Overhead R&D Index		
1968	43.46 + 10.36 + 50.44 =	104.26	2.7531	2.4935
69	45.64 + 10.70 + 53.94 =	110.28	2.6028	2.3574
70	48.12 + 11.14 + 58.31 =	117.57	2.4414	2.2112
71	49.63 + 11.66 + 61.57 =	122.86	2.3363	2.1160
72	51.68 + 12.07 + 63.92 =	127.67	2.2483	2.0363
73	58.52 + 12.58 + 66.70 =	137.80	2.0830	1.8866
74	66.57 + 13.22 + 72.93 =	152.72	1.8795	1.7023
75	72.20 + 13.90 + 79.88 =	165.98	1.7294	1.5663
76	74.42 + 14.64 + 86.50 =	175.56	1.6350	1.4808
77	78.87 + 15.53 + 93.17 =	187.57	1.5303	1.3860
78	86.54 + 16.60 + 101.13 =	204.27	1.4052	1.2727
79	95.86 + 17.81 + 112.30 =	225.97	1.2703	1.1505
80	110.16 + 20.20 + 129.61 =	259.97	1.1041	1.0000
81	113.85 + 21.24 + 151.95 =	287.04	1.0000	

Step 5

Calculate labor (value added), material and overhead weights (percent of total intermediate output).

	Value added	As percent of TIO 60.00
60.01	3,961,100,000	
60.02	1,943,700,000	
60.04	1,945,500,000	
Σ	7,850,300,000	46.1%

Labor 46.1
Overhead 6.8
Material 47.1

Calculation from FY68 of SIC R&D Index.

Material Index x Cost + Labor x weight + Overhead x Weight — New Index

1968 3.2537 x 47.1% + 2.2169 X 46.1% + 2.7531 x 6.8%

1.5300 + 1.0200 .1900 = 2.7400

APPENDIX I (Continued)

Calculation of SIC R&D Index

	Material		Labor		Overhead		SIC R&D Index
1968	3.2537	(.471)	2.2169	(.461)	2.4935	(.068)	2.7240
1969	3.1587	"	2.0948	"	2.3579	"	2.6245
1970	2.8799	"	1.9321	"	2.2112	"	2.3975
71	2.7344	"	1.8160	"	2.1160	"	2.2689
72	2.6477	"	1.7172	"	2.0363	"	2.1772
73	2.5848	"	1.6221	"	1.8866	"	2.0935
74	2.3414	"	1.5354	"	1.7023	"	1.9264
75	1.8135	"	1.4365	"	1.5663	"	1.6228
76	1.7132	"	1.3509	"	1.4808	"	1.5304
7T	1.5890	"	1.3316	"		"	
77	1.4837	"	1.2524	"	1.3860	"	1.3704
78	1.3493	"	1.1615	"	1.2727	"	1.2575
79	1.1453	"	1.0876	"	1.1505	"	1.1190
80	1.0000	"	1.0000	"	1.0000	"	1.0000

LIST OF ABBREVIATIONS AND ACRONYMS

AR	Army Regulation
BEA	Bureau of Economic Analysis
CPI	Consumer Price Index
DARCOM	US Army Materiel Development and Readiness Command
IPD	Implicit Price Deflator
OSD	Office of the Secretary of Defense
PM	Program Manager
PPI	Producer Price Index
R&D	Research and Development
RDTE	Research Development Testing and Evaluation
RPV	Remotely Piloted Vehicle
SIC	Standard Industrial Classification
USAAVRADCOM	US Army Aviation Research and Development Command